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FROM: PROI (TI) (STINFO) 16 Jun 2000

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-AB-2000-131**
C.T. Liu, "Strain Rate Effect on Crack Opening and Growth in a Particulate Composite Material at Low Temperature"

3rd International Conference on Mechanics of Time Dependant Materials **(Statement A)**
(Erlangen, Germany, 17-20 Sep 2000) **(Submission Deadline: 26 June 2000)**

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Strain Rate Effect on Crack Opening and Growth in a Particulate Composite Material at Low Temperature

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INTRODUCTION

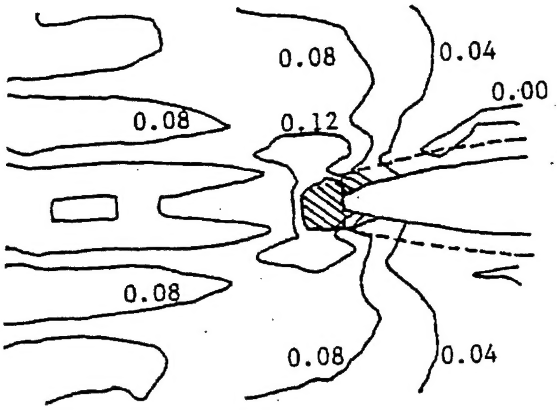
Over the past years, a considerable amount of work has been done in studying crack growth behavior in highly filled polymeric materials (1-4). These materials consist of hard particles embedded in soft polymeric binder, such as rubber, and behave ~~behavior~~-like viscoelastic materials. Therefore, the mechanical and fracture behaviors of such materials can be strongly influenced by the loading rate, temperature, and material microstructure. Thus, in order to obtain a fundamental understanding of the crack growth behavior in the particulate composite materials, the effects of loading rate and temperature on the crack growth behavior need to be determined.

In this study, edge-cracked sheet specimens (Fig. 1) made from polybutadiene rubber embedded with hard particles were used to study the effects of strain and specimen thickness on the crack growth behavior at –65°F. In this program, two strain rates (0.05 min^{-1} and 0.25 min^{-1}) and two specimen thicknesses (2.54 mm and 12.7 mm) were considered. Prior to testing, a coarse grating of 0.2 mm squares was deposited in the surface of the specimen. During the crack propagation tests, photographs were taken at various time intervals. The raw data obtained from the test were the displacement fields, the crack length, the time, and the load. The raw data were used to calculate the strain fields near the crack tip, the crack opening displacement, and the failure process zone size. The experimental data were analyzed and the effects of loading rate and specimen thickness on the aforementioned parameters are discussed.

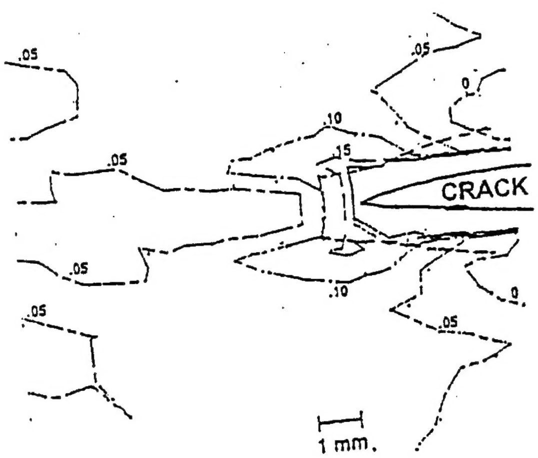
RESULTS AND DISCUSSION

It is well known that, on the microscopic scale, a highly filled polymeric material can be considered an inhomogeneous material. When these materials are stretched, the different sizes and distribution of filled particles, the different crosslink density of polymeric chains, and the variation in bond strength between the particles and the binder can produce highly nonhomogeneous local stress and strength fields. Depending on the magnitude of the local stress and the local strength, damage can be developed in the material, especially near the crack tip region. The damage developed in the material may be in the form of microvoids or microcracks in the binder or dewetting between the binder and the filler particles. Damage growth in the material may occur as material tearing or as successive nucleation and coalescence of the microcracks. These damage processes are time dependent and are the main factor responsible for the time sensitivity of strength degradation as well as the fracture behavior of the material.

Typical sets of photographs showing the crack surface profiles are shown in Fig. 2. The local behavior shown can be regarded as typical, except for the higher rate and thicker specimen case, for the material investigated and the two strain rates considered in this study. Figure 2 depicts the crack opening and growth that consisted of a blunt-growth-blunt-growth process. Experimental data also reveal that voids are formed in a highly damaged zone, known as the failure process zone, ahead of the crack tip during blunting following by growth during which the crack resharpened. As the crack propagates, due to the random nature of the damage developed at the crack tip, the crack path was locally an undulating path. However, in a global sense, the crack grew in a plane normal to the direction of the applied load. Figure 3 shows the crack tip profiles when the thicker specimen was tested at the higher strain rate. At the higher strain rate, the void development was strongly suppressed and the crack growth path is straight across the specimen. This phenomenon is believed due to the reason that, at -65°F, the bond strength and the binder strength increase significantly, and the load transfer mechanism is considerably



(a) t = 2.54mm
space



(b) t = 12.7 mm

Figure 5. Iso-strain contours
(strain rate = 0.05 min^{-1})
remove
space

PAGES FIG 1 thru 4

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